PERFORATION PLATES AND VESSEL ELEMENTS OF THE STEM SAPWOOD IN NEW ZEALAND *Nothofagus Blume* (FAGACEAE) WITH PARTICULAR REFERENCE TO THEIR LENGTHS.

T.M. MIDDLETON

Department of Plant and Microbial Sciences,
University of Canterbury,
Private Bag, Christchurch. New Zealand.

ABSTRACT

A detailed scanning electron microscopic study involving over 1000 micrographs and 55 trees was made of the vessel elements of the stem wood of the four species and two varieties of New Zealand *Nothofagus* Blume:- (mountain beech) *N. solandri* var. *cliffortioides* (Hook.f.) Poole., (black beech) *N. solandri* var. *solandri* (Hook.f.) Oerst., (hard beech) *N. truncata* (Col.) Ckn., (red beech) *N. fusca* (Hook.f.) Oerst., and (silver beech *N. menziesii* (Hook.f.) Oerst.

The predominant perforation plate type in the vessel end walls in all five taxa is simple, although part-scalariform and scalariform perforation plates may occur. Mismatching or combination perforation plates are rare in beech. Simple to scalariform combination perforation plates were observed in *N. solandri* var. *solandri* and *N. fusca.* An unusual combination perforation plate exhibiting a reticulate tendency was noted in *N. solandri* var. *solandri*. Perforation plate lengths, and vessel element lengths were measured. A regression analysis showed that vessel element length and very little influence on perforation plate length. *N. fusca* and *N. truncata* have wider, longer vessel elements than the other three taxa. *N. solandri* var. *solandri* has the narrowest and shortest vessel elements. The number of vessel elements that comprise a vessel was estimated.

KEYWORDS. beech, simple perforation plate, scalariform perforation plate, combination perforation plate, length, vessel element, stem wood.

INTRODUCTION

Perforation plate lengths and vessel element lengths were not included in previous descriptions of New Zealand *Nothofagus* wood. (Parham, 1930, 1933; Dadswell & Ingle, 1954; Butterfield & Meylan, 1980). To understand more fully the conducting pathways in *Nothofagus* wood vessel elements were measured.

The vessel element walls of all five taxa of *Nothofagus* are smooth. There are no warts, or helical thickenings in the vessels of normal and tension wood. The walls of the vessel element tails (ligules) are also smooth. Intervessel pitting is predominantly opposite; although alternate pitting may be present. Some elements exhibit part-scalariform or scalariform intervessel pitting. Ray to vessel pits form prominant cross-fields.

MATERIALS AND METHODS

Random samples from beech trees (poles) with approximately 20 cm circumference were taken between 1 - 2 metres stem height. Small pieces of sapwood were macerated according to Jeffery's technique (Johansen, 1940) and examined under a Reichert Visopan projection microscope. Statistical analyses relate to 25 random trees representing the five taxa. The lengths of 100 perforation plates per taxon were measured. The Teddy Bear package (Wilson, 1979) was used for statistical analysis. Preparation of wood for S.E.M. follows that described by Exley et al., (1973, 1977). All micrographs were taken on the Cambridge Stereoscan 250 Mark 2.

RESULTS AND DISCUSSION

The majority of perforation plate types in all five taxa of New Zealand *Nothofagus* are simple (Figure 1).

Openings in the oblique adjacent element end walls normally coincide in a simple to simple (Figure 1B - 1H) or scalariform to scalariform arrangement where only one type of plate is present (Figures 2A, 2C, 2D, 2F), (Butterfield and Meylan, 1975). This is the normal state in *Nothofagus*. The number of bars in scalariform perforation plates are variable. Both branched and unbranched scalariform perforation plates may be present in the same tree. Meylan and Butterfield (1973, 1975) recorded simple to reduced scalariform perforation plates in *N. truncata* and combination perforation plates in *N. fusca*. They observed mismatching and intermediate perforation plates in *N. solandri* var. *cliffortioides*. They noted that sometimes a few bars develop on the simple half of the combination plate; or the number of bars on the scalariform half of the combination may be reduced or absent. Matching combination plates with coinciding perforations are rare in beech. Figures 3 and 4 show simple to scalariform combination perforation plates in neighbouring vessel elements in *N. solandri* var. *solandri*. Here the bars are branched, and there is evidence of dichotomous branching. The lower portion of the perforation plate featured in Figure 4 is slightly reticulate. Remains of microfibrillar webs were observed in scalariform perforation plates in *N. solandri* var. *solandri*, *N. truncata*, *N. fusca*, and *N. menziesii*. In *Nothofagus* microfibrillar webs are present in the central region of scalariform perforation plates (Figures 2D & 2F). Previously Meylan and Butterfield (1972, 1975) and Butterfield and Meylan (1975) suggested that microfibrillar webs are restricted to "the last few openings at each end of the perforation plate in mature wood".

The lengths of 500 perforation plates were measured (100 perforation plates per taxon). The means and ranges of the perforation plate lengths are presented in Table 1. The measurements show that *N. solandri* var. *solandri* possesses the shortest perforation plates. The shortest recorded length was 40 microns. Duncan's New Multiple Range Test distinguished *N. solandri* var. *solandri* from the other species. Table 2 shows that *N. fusca* has both the shortest and longest vessel elements. Vessel element length has very little influence on perforation plate length. The degree of covariance is very small. Only 14% of the variation is accounted for by the regression equation.

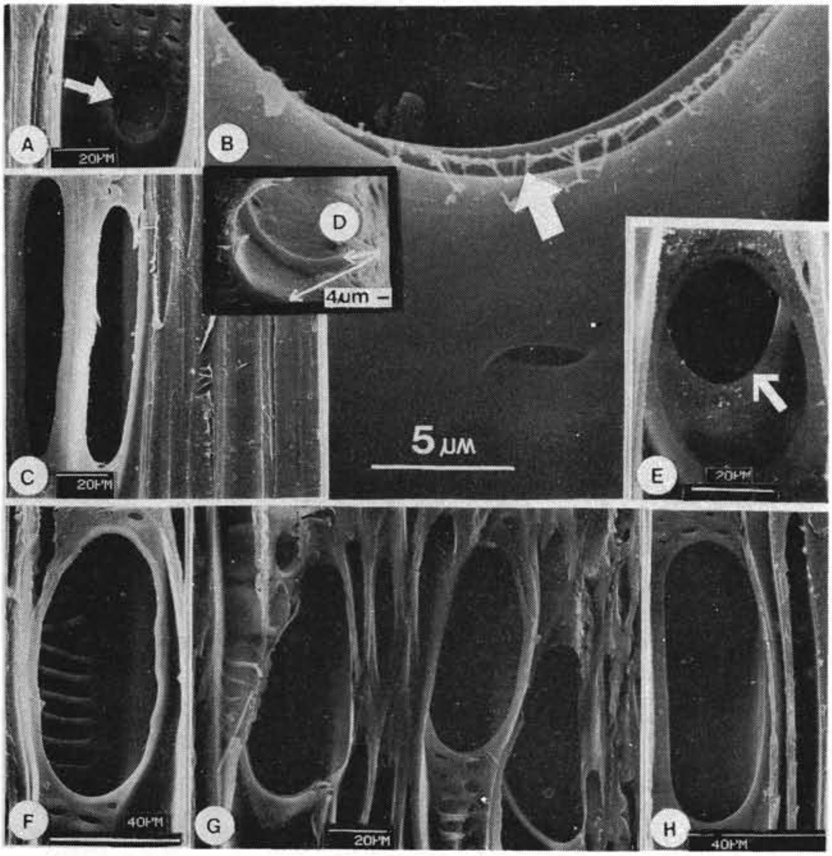

Fig. 1. SIMPLE PERFORATION PLATES IN *Nothofagus*.

1A A perforation plate in the side wall of a vessel element. (arrowed). *N. menziesii*. (radial longitudinal view).

1B Remains of microfibrillar webs and the middle lamellae (arrowed) of a simple perforation plate. *N. menziesii*. (radial longitudinal view).

1C Two perforation plates in *N. menziesii*. (radial longitudinal view).

1D Looking down a series of perforation plates (arrowed) *N. menziesii* (transverse view).

1E,F,G,H - Simple perforation plates in *N. solandri* var. *cliffortioides*. (radial longitudinal view).

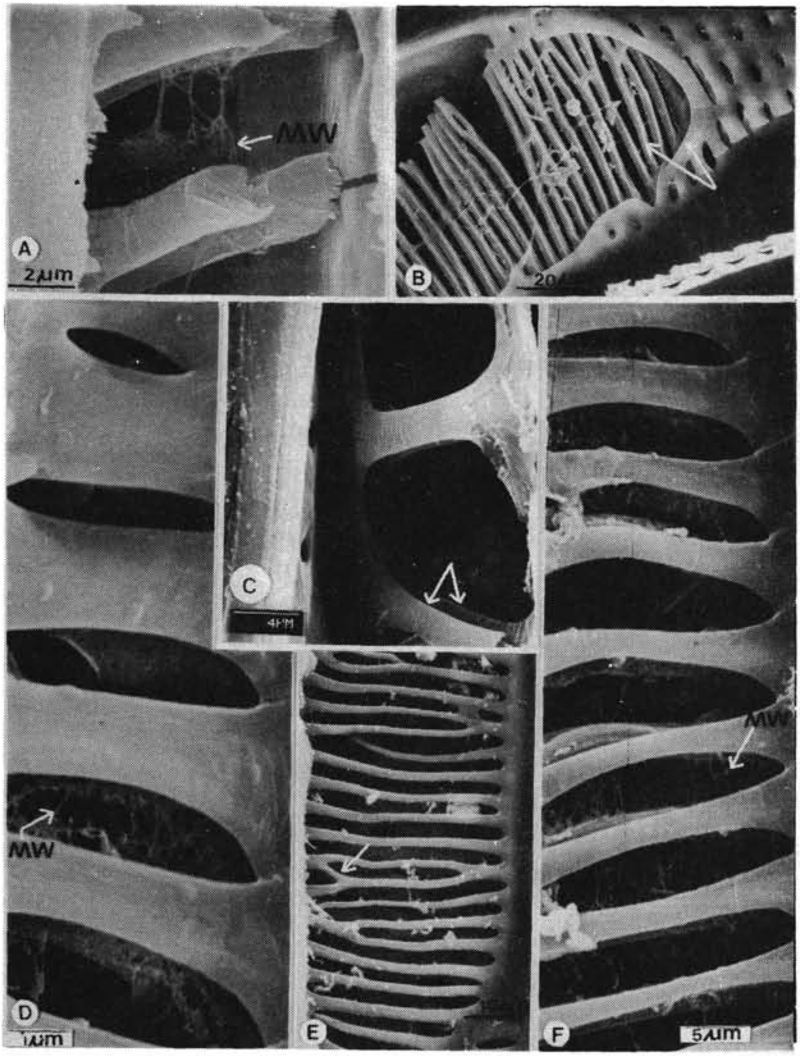

Fig. 2 SCALARIFORM PERFORATION PLATES IN *Nothofagus*.

2A Detail of matching bars and microfibrillar webs (MW) in *N. menziesii*. (tangential longitudinal view).

2B A simple to scalariform combination perforation plate in *N. solandri* var.*solandri*. (raidial longitudinal view).

2C Detail of matching bars (arrowed) in *N. menziesii*. (tangential longitudinal view).

2D Microfibrillar webs (MW) in *N. menziesii*. (radial longitudinal view).

2E The scalariform side of a scalariform to simple combination perforation plate in *N. truncata*. (radial longitudinal view).

2F Microfibrillar webs (MW) in *N. menziesii*. (radial longitudinal view).

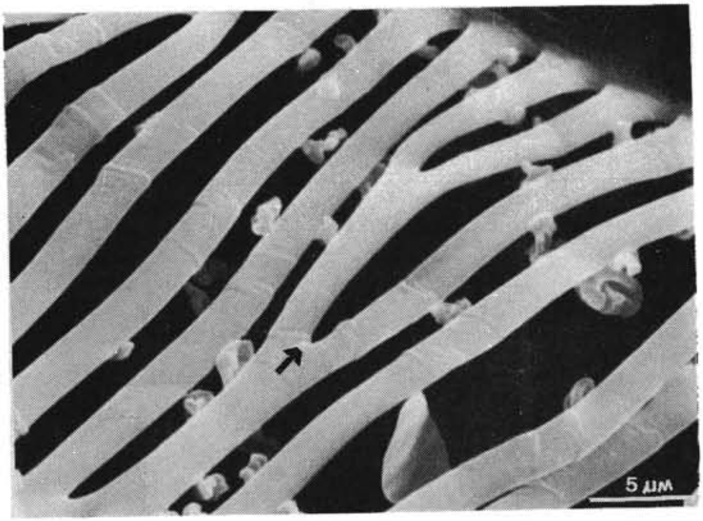

Fig. 3 Detail of dichotomous branching (arrowed) in the scalariform side of a simple to scalariform combination perforation plate between two vessel elements in *Nothofagus solandri* var. *solandri*. (Radial longitudinal view x 3000).

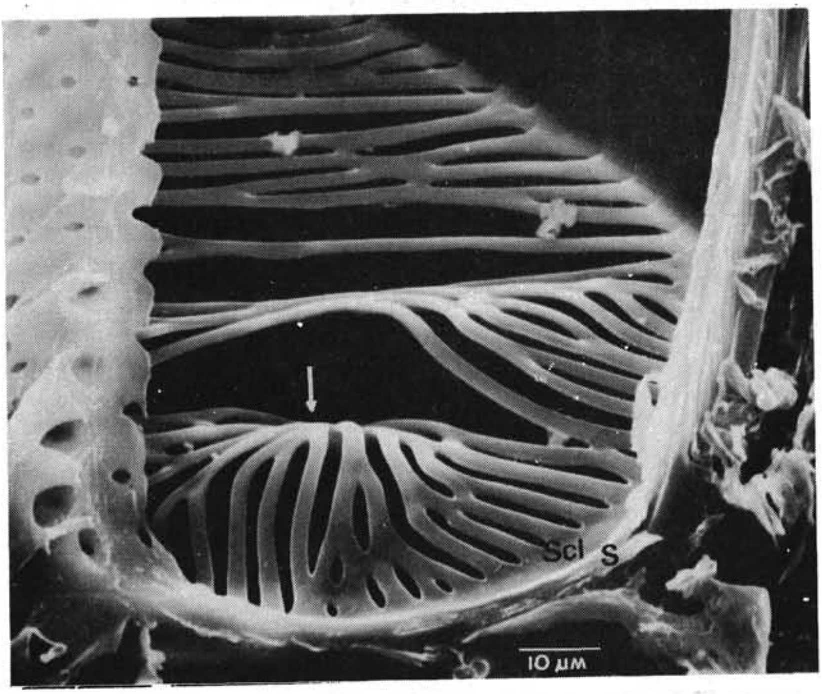

Fig. 4 A simple (S) to scalariform (Scl.) combination perforation plate between two vessel elements in *Nothofagus solandri* var. *solandri*. Note the reticulate tendency (arrowed) near the base of the plate. (Radial longitudinal view x 970).

Table 1. The means and range of perforation plate lengths measured in microns for N.Z. *Nothofagus* taxa.

	Mean µm	SD	Range µm
N. solandri var. *cliffortiodes.*	79.5	5.2	50-123
N. solandri var. *solandri.*	66.3	3.2	40- 94
N. truncata	84.0	1.6	54-120
N. fusca.	89.0	6.8	58-136
N. menziesii.	85.0	6.8	50-127

Table 2. The means and ranges of vessel element lengths measured in microns for N.Z. *Nothofagus* taxa.

	Mean µm	SD	Range µm
N. solandri var. *cliffortioides.*	447.3	30.0	253-749
N. solandri var. *solandri.*	338.5	31.8	170-682
N. truncata.	472.8	34.9	277-760
N. fusca.	434.8	52.2	150-840
N. menziesii.	438.3	59.5	230-640

The number of vessel elements that comprise one vessel (conduit) may be estimated from data on element length and from data on conduit length. Unpublished results obtained from latex paint infusion experiments in *N. fusca* suggest an average conduit length of 190,000 microns. Thus, if the average length of each vessel element is 435 microns then a conduit could consist of 437 elements joined end to end.

Aloni and Plotkin (1985) also utilized the paint infusion method to determine vessel - length in the stem of *Coleus blumei* Bth. They estimated that the longest vessels of 180,000 microns were built up of 450 - 550 vessel elements. It is notable that although *Coleus* and *Nothofagus* belong to different families, both have a similar number of elements that comprise a vessel.

Middleton (1987) observed from S.E.M. micrographs that there is no obvious difference in vessel element length in vessels present in either aggregate ray zones or in normal wood of *Nothofagus.*

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